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Associations between insomnia, sleep duration and poor work ability

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ABSTRACT

Objective: The aim of this study was to examine the independent and joint effect of insomnia and objective sleep duration on poor work ability.
Methods: In this cross-sectional study, a total of 2820 Chinese manufacturing workers were categorized as insomnia patients and individuals with normal sleeping pattern by interview according to DSM-IV criteria. Sleep duration was classified into four categories: ≥7 h, 6–7 h, 5–6 h, and <5 h according to objective sleep duration of Watch-PAT-200 test. Work ability was assessed using the Chinese Work Ability Index (WAI) questionnaire. Regression analysis examined the independent and joint association of sleep duration and insomnia with poor work ability, after adjusting for various confounding factors.
Results: Insomnia and objective short sleep duration were both independently associated with poor work ability. Compared with the normal sleeping and ≥7 h sleep duration group, the highest risk of poor work ability was in the insomnia patients with <5 h sleep duration [odds ratio (OR) 3.43, 95% confidence interval (CI) 1.87–5.23], followed by the individuals with insomnia who slept 5–6 h (OR 2.03, 95% CI 1.42–2.67).
Conclusions: Insomnia and sleep duration in workers are both separately and together associated with increased risk of poor work ability. Objective sleep duration should be taken into consideration when assessing the work ability of people with insomnia.

Introduction

Insomnia is one of the most common health problems among the working population: 30%–50% occasionally experience insomnia symptoms, and up to 10% meet the criteria for clinical diagnosis of insomnia [1,2]. Many studies have established that insomnia is associated with deterioration in work ability, including: reduced physical and mental function such as fatigue, anxiety and inability to perform complex tasks; reduced career progression and job satisfaction; excess absenteeism; reduced work performance; and work disability [3–9].

Sleep duration has also been associated with morbidity and mortality in many previous studies [10,11]. However, only a few studies have examined the association between sleep duration and work ability, with ambiguous results [12–15]. For instance, short sleep duration (≤5 h) has been shown to predict sickness absence [12] and retirement through disability [13]. Another recent study has found that people who sleep ≤6 h have a higher risk of sickness absence than those who sleep for 7 h, with adjustment for age and gender. However, this association disappears after adjustment for covariate factors [14]. In contrast, the Hordaland Health Study has shown that short sleep duration is not significantly associated with subsequent work disability [15]. Sleep duration in these previous studies was based on self-reports, which may not be representative of habitual sleep duration, and there was no objective sleep measurement. Therefore, some misclassification may have occurred and the effect of sleep duration on risk of poor work ability might have been overestimated. It has been shown that self-reported sleep duration is moderately correlated with sleep duration measured using wrist actigraphy ($r = 0.47$); the former is more likely to overestimate the latter by 0.8 h on average, and this overestimate escalates in particular with short sleep duration [16]. Thus, the question whether short sleep duration is associated with an increased risk for poor work ability remains open to further investigation.

In addition to independent effects of sleep duration and insomnia on health, some studies have examined their joint effect on various health outcomes such as hypertension [17], type 2 diabetes [18], neurocognitive impairment [19] and mortality [20]. This earlier evidence further suggests that short sleep, particularly objectively measured, could serve as a biological marker for severity of insomnia and explain the increased health risks among those suffering from insomnia and short sleep. Thus, when examining sleep duration, its combined effects with insomnia need to be considered. To date, only two studies have examined the joint associations of subjective sleep duration and insomnia symptoms with deterioration in work ability, and the results were inconsistent. The Helsinki Health Study showed that combination of subjective short sleep duration and insomnia symptoms was significantly associated

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with all-cause disability retirement [15]. However, the joint association was not found in another recent report of the study [14].

These previous studies have relied on loose definitions of insomnia, and subjective questionnaires do not include any criteria of frequency or severity, which may have overestimated the impact of insomnia on work ability. Moreover, the concept of work ability is broad, comprising the physical, psychological, and social capability of a worker to perform and interact within their work, and the individual's specific work demands, health conditions, and mental resources [21]. Most of the research on work ability of individuals with insomnia has used variables such as absenteeism and work disability, which are low-incidence events and may not fully capture the nature or scope of work ability deterioration. Other variables, which may give a fuller picture, such as cognitive impairments, mood problems that affect relationships with co-workers, and social functioning, have received less attention. Finnish researchers have constructed the Work Ability Index (WAI) to assess work ability [21,22]. They described work ability as the interaction of individual determinants (health, competence and attitudes) and the work environment. The WAI combines subjective experiences of one's ability to cope with physical and mental requirements at work (performance at work) with information on diseases and consequent functional limitations, sick leave and mental resources at work (enjoying daily tasks, active and vital life, optimism about the future) [22]. Measuring work ability has been developed as a valuable tool to tailor disability interventions at an individual level [23].

Although insomnia and subjective sleep duration both affects work ability, it is not known whether objective sleep duration is associated with poor work ability, and whether both insomnia and objective sleep duration affect work ability to a similar extent. We hypothesized that insomnia is associated with poor work ability and that its effect is exacerbated by objective sleep duration. We therefore aimed to examine the independent and joint association of objective sleep duration and insomnia with poor work ability, adjusting for various social and work- and health-related factors, among Chinese manufacturing workers.

Methods

Participants and procedures

The study is part of the Occupational Health Study of Manufacturing Industry Workers (OHSMIW) in China, and was conducted between October 21, 2011 and July 12, 2012. The target population was all blue-collar employees working in 123 state-owned and 163 private manufacturing companies in Urumqi city, Xinjiang province, China. Using a three-stage stratified sampling method, 10 state-owned and eight private companies were selected first, based on the Chinese Standard Industrial Classification of the nature of the companies. Then, based on the size of company, we randomly selected two large-sized company (>1000 workers), two medium-sized (300–1000 workers) companies and one small-sized company (<300 workers) from selected state-owned companies, and selected one large-sized company, two medium-sized companies and one small-sized company from selected private companies. Finally, we selected 600 workers from large-sized companies, 250 from medium-sized companies, and 100 from small-sized companies by applying computer-generated random numbers to the manager's lists of employees, and workers who had worked in the company for at least 1 year were selected for interview, excluding those employed on a part-time basis or in management roles. A total of 3000 workers were recruited for interview. With the assistance of the company managers, an announcement was sent to employees explaining that the survey was designed "to better understand how sleep problems affect the work ability of people," that respondents were selected randomly, that participation was voluntary, that responses were confidential, that participation would not affect health care benefits, and that an incentive of RMB 20 Yuan was offered for participation. Finally, 2910 workers agreed to take part (response rate 97.0%). Once an individual was identified and agreed to participate, a face-to-face interview was conducted during annual occupational health screening. All interviews were conducted privately by trained interviewers using a questionnaire including sociodemographics, sleep quality, work ability, behavior risk factors and occupational stress. A common interview protocol was utilized across the nine study companies, in order to achieve homogeneity in interview and data collection procedures. The workers were simultaneously instructed by our research staff to complete sleep duration measurement in home using the Watch-PAT-200® device for three nights. Among the respondents, 90 workers were excluded because of the non-response to one or more of the variables in the interview or missing data in sleep duration. Thus, the final analysis involved 2820 workers.

After the interview, those who were screened positive in the Athens Insomnia Scale (AIS) were asked to undergo clinical reappraisal. Blinded clinical interviewers who were experienced sleep medicine experts carried out structured clinical interviews to establish a diagnosis of insomnia based on the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV). The 2820 employees were classified as 692 insomnia patients and 2128 individuals with normal sleeping patterns. The characteristics of the study participants are presented in Table 1.

Ethical considerations

All the participants gave written informed consent after receiving details of the study aims and protocol. The study was approved by the Ethics Committees of Xinjiang Medical University.

Insomnia

Insomnia was assessed with the AIS, which was developed by Soldatos and colleagues to assess the severity of insomnia based on the International Classification of Diseases 10th Revision (ICD-10) diagnostic criteria [24]. It is a self-reported questionnaire consisting of eight items; the first five assess difficulty with sleep induction, wakening during the night, early morning wakening, total sleep time, and overall quality of sleep; and the last three items pertain to the sense of well-being, overall function, and daytime sleepiness. The usual time frame for responding is the previous month. Each item of AIS can be rated 0–3, with 0 corresponding to no problem at all and 3 to a very serious problem. This gives a total score ranging from 0 to 24. A total score >6 indicates insomnia symptoms. The Chinese version of the questionnaire has good overall psychometric properties and is a reliable screening tool for diagnosis of insomnia [25]. Cronbach's α was 0.81, and the 2-week test–retest reliability was 0.80. The scale had a two-factor structure, and was significantly correlated with sleep–wake variables [25,26].

Clinical reappraisal was carried out with a subsample of respondents who were screened for insomnia symptoms using AIS. Blinded clinical interviewers who were highly experienced sleep medicine experts carried out structured clinical interviews to establish a diagnosis of insomnia with DSM-IV. The DSM-IV criteria for insomnia include difficulty falling asleep, difficulty maintaining sleep, or experiencing nonrestorative sleep for a period of $\geq$1 month. In addition, it is a prerequisite that sleep disturbance significantly impairs daily function. The interviews were conducted by three qualified psychiatrists. The clinical interviews underwent training in clinical diagnosis work at a 3-day workshop. The workshop gave an overview of the project and covered assessment procedures, techniques for diagnosis interviews, potential difficulties in the interview, mock interviews, and quality assessment.

Objective sleep duration

Gold standard measurement for sleep duration was in-laboratory polysomnography (PSG). However, the disadvantages of overnight

Table 1
Sociodemographic, psychosocial, work and sleep characteristics of the study population (n = 2820).

Variables	n	Insomnia		Normal sleeping		Objective Sleep duration							
						≥7 h		6–7 h		5–6 h		<5 h	
		%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Total (n)	2820	24.5	23.0, 26.1	75.5	73.9, 77.0	49.0	47.2, 50.9	33.0	31.3, 34.7	14.0	12.7, 15.3	4.0	3.3, 4.7
Age													
<30	1364	16.5	14.5, 18.5	83.5	81.5, 85.5	59.7	57.1, 62.3	29.4	27.0, 31.8	9.7	8.1, 11.2	1.5	0.8, 2.1
30–40	527	28.1	24.2, 31.9	71.9	68.1, 75.8	44.2	40.0, 48.5	33.0	29.0, 37.0	16.9	13.7, 20.1	5.7	3.7, 7.7
40–	682	38.8	35.1, 42.5	61.2	57.5, 64.9	31.8	28.3, 35.3	40.4	36.7, 44.1	21.2	18.2, 24.3	6.3	4.5, 8.1
50–	247	21.9	16.7, 27.0	78.1	73.0, 83.3	47.8	41.5, 54.0	32.0	26.2, 37.8	12.1	8.1, 16.2	8.1	4.7, 11.5
Sex													
Male	2300	24.0	22.2, 25.7	76.0	74.3, 77.8	52.0	49.9, 54.0	30.9	29.0, 32.8	13.7	12.3, 15.1	3.4	2.7, 4.2
Female	520	27.1	23.3, 30.9	72.9	69.1, 76.7	36.0	31.8, 40.1	42.3	38.1, 46.6	15.2	12.1, 18.3	6.3	4.3, 8.4
Income (Yuan)													
<2000	1733	20.7	18.8, 22.6	79.3	77.4, 81.2	53.2	50.9, 55.6	30.9	28.8, 33.1	11.2	9.7, 12.7	4.7	3.7, 5.7
2000	1087	30.6	27.9, 33.4	69.4	66.6, 72.1	42.3	39.4, 45.3	36.3	33.5, 39.2	18.5	16.2, 20.8	2.8	1.8, 3.7
Length of service													
<10 y	1617	18.3	16.4, 20.2	81.7	79.8, 83.6	59.0	56.6, 61.4	29.0	26.8, 31.3	9.8	8.3, 11.2	2.2	1.5, 2.9
10–20 y	451	30.6	26.3, 34.9	69.4	65.1, 73.7	38.6	34.1, 43.1	36.4	31.9, 40.8	19.1	15.4, 22.7	5.8	3.6, 7.9
20 y	752	34.4	31.0, 37.8	65.6	62.2, 69.0	33.6	30.3, 37.0	39.4	35.9, 42.9	20.1	17.2, 22.9	6.5	4.8, 8.3
Education level													
Junior college or lower	2390	25.1	23.4, 26.9	74.9	73.1, 76.6	50.5	48.5, 52.5	31.7	29.8, 33.5	13.6	12.3, 15.0	4.1	3.3, 4.9
Bachelor or higher	430	21.2	17.3, 25.0	78.8	75.0, 82.7	40.5	35.8, 45.1	40.5	35.8, 45.1	16.0	12.6, 19.5	3.0	1.4, 4.6
Marital status													
Single	1232	15.3	13.3, 17.3	84.7	82.7, 86.7	59.2	56.4, 61.9	29.6	27.1, 32.2	9.3	7.7, 11.0	2.1	1.3, 2.9
Married	1551	31.4	29.1, 33.7	68.6	66.3, 70.9	41.7	39.3, 44.2	35.4	33.0, 37.8	17.4	15.5, 19.3	5.3	4.2, 6.4
Divorced/widowed	37	45.9	29.9, 62.0	54.1	38.0, 70.1	18.9	6.3, 31.5	43.2	27.3, 59.2	27.0	12.7, 41.3	8.1	0.0, 16.9
Sleep duration													
≥7 h	1382	21.1	19.0 23.3	78.9	76.7, 81.0	N/A		N/A		N/A		N/A	
6–7 h	931	26.0	23.2, 28.8	74.0	71.2, 76.8	N/A		N/A		N/A		N/A	
5–6 h	395	29.9	25.4, 34.4	70.1	65.6, 74.6	N/A		N/A		N/A		N/A	
<5 h	112	35.7	26.8, 44.6	64.3	55.4, 73.2	N/A		N/A		N/A		N/A	
Sleep-promoting agent													
No	2642	24.4	22.8, 26.1	75.6	73.9, 77.2	51.2	49.3, 53.1	32.2	30.5, 34.0	13.2	11.9, 14.5	3.4	2.7, 4.1
Yes	178	26.4	19.9, 32.9	73.6	67.1, 80.1	16.9	11.4, 22.4	44.4	37.1,51.7	25.8	19.4, 32.3	12.9	8.0, 17.8
Work ability													
Good work ability	2239	21.0	19.3, 22.7	79.0	77.3, 80.7	52.3	50.3, 54.4	32.2	30.2, 34.1	12.1	10.7, 13.4	3.5	2.8, 4.3
Poor work ability	581	38.2	34.3, 42.2	61.8	57.8, 65.7	36.1	32.2, 40.1	36.3	32.4, 40.2	21.5	18.2, 24.9	5.7	3.8, 7.6
Current smoker	682	33.0	29.5, 36.5	67.0	63.5, 70.5	44.3	40.6, 48.0	33.0	29.5, 36.5	12.3	9.9, 14.8	3.7	2.3, 5.1
Obesity	722	31.2	27.8, 34.5	68.8	65.5, 72.2	45.7	42.1, 49.3	34.2	30.7, 37.7	12.7	10.3, 15.2	3.7	2.4, 5.1
Current alcohol consumption	424	31.6	27.2, 36.0	68.4	64.0, 72.8	33.5	29.0, 38.0	28.5	24.2, 32.8	10.8	7.9, 13.8	3.3	1.6, 5.0
Comorbidities													
Diabetes	21	0.9	0.2, 1.6	0.7	0.3, 1.1	0.2	0.0, 0.5	0.6	0.1, 0.9	1.8	0.5, 3.1	4.5	0.6, 8.3
Cardiovascular diseases	69	3.3	2.0, 4.7	2.2	1.5, 2.8	0.9	0.4, 1.4	2.3	1.3, 4.8	5.6	3.3, 7.8	12.5	6.4, 18.6
Asthma	9	0.3	0.0, 0.7	0.3	0.1, 0.6	0.1	0.0, 0.3	0.4	0.0, 0.4	0.3	0.0, 0.7	1.8	0.0, 4.2
Osteoarthrosis	34	1.3	0.5, 2.1	1.2	0.7, 1.6	0.6	0.2, 1.0	0.9	0.3, 1.4	3.0	1.3, 4.7	5.4	1.2, 9.5
Depression	31	1.4	0.6, 2.3	1.0	0.6, 1.4	0.9	0.4, 1.4	0.0	0.0	2.3	0.8, 3.8	8.0	3.0, 13.1
Anxiety	36	1.3	0.5, 2.1	1.3	0.8, 1.7	0.1	0.0, 0.3	0.8	0.2, 1.1	4.1	2.1, 6.0	9.8	4.3, 15.3
Chronic pain	33	1.2	0.4, 2.0	1.2	0.7, 1.6	0.5	0.1, 0.9	1.2	0.5, 2.1	1.5	0.3, 2.7	8.0	3.0, 13.1

PSG, such as high cost, backlog of the sleep centers, and the need for qualified personnel, limited usage of PSG in many study participants. In the study, the Watch-PAT-200® device was selected to measure objective sleep duration, because there were some advantages: (1) it does not require a sleep technician, and adjustments can be learned and performed by any personnel; (2) scoring is automated; (3) hospitalization is not required; and (4) there were no significant difference in total sleep time between the Watch-PAT and standard PSG [27].

All participants were asked to undergo objective sleep time appraisal for three nights at home using the Watch-PAT-200® device. Watch-PAT-200® (Itamar Medical Ltd., Caesarea, Israel) is a portable instrument capable of measuring four channels which is classified in the third category according to the American Sleep Disorders Association (ASDA) criteria for diagnostic methods. The channels are: (1) PAT (peripheral arterial tone), (2) pulse oximetry, (3) heart rate, and (4) actigraphy. PAT signal, oximetry, and oxygen saturation measured by finger-mounted probe and the data coming from motion sensor (actigraphy) in the device are all continuously recorded digitally on the SD card which is located in the device. Oximetry probe was applied on the finger tip with a special disposable band to transmit blood oxygen saturation to the recorder device through a pulse oximetry module. The snoring sensor was fixed on the trachea with the help of a special double-sided tape to measure snoring intensity in dB unit. A body position sensor was placed on the patient's chest region by means of a special double-sided tape to perceive body position in five different configurations (standing, supine, right, left, and sitting). After the sleep test, all these data were automatically transferred to the computer and these data were analyzed and reported with zzzPAT® software [28]. Recording time duration, sleep duration, and awake duration were automatically calculated with Watch-PAT-200. Because only 69 (1.9%) participants slept for >9 h, they were combined into the ≥7-h category to increase statistical power.

According to the objective sleep time, sleep duration was further categorized into <5, 5–6, 6–7 and ≥7 h. Based on mean total sleep time of Chinese people in previous studies [29], long sleep duration and short sleep duration were defined as usual sleep duration >9 h and usual sleep duration <7 h respectively. The joint variable was an eight-class variable with mutually exclusive categorization. Those who reported that they slept for ≥7 h and reported no insomnia served as a reference category. Each level of objective sleep duration was divided into those with and those without insomnia.

Work ability

The Chinese version of the WAI questionnaire was used to assess perceived work ability [30], which was originally developed by the Finnish Institute of Occupational Health (FIOH) [21]. The questionnaire consists of seven items: current work ability compared with lifetime's best; work ability in relation to the demands of the job; number of current diseases diagnosed by a physician; estimated work impairment due to disease; sick leave during the past year; own prognosis of work ability 2 years from now; and mental resources (worker's life in general, both at work and during leisure time). WAI was calculated by summing up the estimated points for each item. In each item, a higher score indicated better work ability. The total scores of workability based on the WAI ranged from 11 to 56. Individuals with a WAI score ≤36 were classified as having poor work ability, and those with a score ≥37 were classified as having good work ability [31,32]. Previous research has demonstrated that the measure has adequate test–retest reliability (0.83), construct validity, and predictive validity [30,32].

Confounding factors

Occupational stress was assessed based on the Chinese version of the Occupational Stress Inventory (OSI-R), originally developed by Ospow [33]. The OSI-R is divided into three subscales: Occupational Role Questionnaire (ORQ), Personal Strain Questionnaire (PSQ), and Personal Resources Questionnaire (PRQ). The OSI-R based on the transactional model including work environmental stressors, resultant psychological strain, and available coping resources has been widely used among the Chinese population with good reliability and validity [34,35]. The ORQ consists of four subscales pertaining to several work roles associated with stress, including role overload (RO), role insufficiency (RI), role ambiguity (RA), role boundary (RB), responsibility (R) and physical environment (PE). The PSQ subscale measures the level of occupational strain, including vocational strain (VS), psychological strain (PYS), interpersonal strain (IS) and physical strain (PHS). The PRQ measures four sets of coping behavior: recreation (RE), self-care (SC), social support (SS) and rational/cognitive coping (RC). Each subscale includes 10 items. Each of the items can be scored on a Likert scale from 1 (lowest) to 5 (highest). The possible responses are: never (1), rarely (2), sometimes (3), frequently (4) and always (5). The total score was calculated by summing the items. Respondents were classified as having high and low level work stressors, using the standard scoring algorithm based on the general population of the China [35]. Comorbid diseases were based on self-reported doctor-diagnosed diseases associated with sleep and work disability (diabetes, cardiovascular diseases, asthma, osteoporosis, osteoarthrosis, depression, anxiety and chronic pain).

Sociodemographic characteristics, namely age, gender, educational level, monthly income, marital status, and length of service were self-reported. Educational level was dichotomized as "Junior college or lower" and "Bachelor degree or higher". Marital status was assessed as "single," "married," and "divorced or separated". Monthly income was divided into "<2000 yuan," and "≥2000 yuan" according to the payment scale for manual workers. Length of service was classified as "<10 years," "10–20 years" and "≥20 years". Obesity was defined as body mass index of 28 or more, and it was calculated based on self-reported heights and weights. Frequency of cigarette smoking was also assessed with one question: "Do you smoke cigarettes?" (yes, daily; yes, occasionally; and no, never). Weekly alcohol use was measured with one specific item: Current alcohol consumption was categorized into no (never or rarely) or yes (often or regularly). Sleep-promoting agent utilization (i.e., prescribed and over-the-counter) was assessed with the following questions: "During the past month, have you taken prescribed medication to help you sleep?" (yes, daily; yes, occasionally; and no, never).

Statistical analyses

Statistical analyses were performed using SPSS version 17.0. Basic descriptive statistics were calculated to determine sample characteristics. Logistic regression models were used to assess the independent association of the insomnia and objective short sleep duration with poor work ability. We adjusted for major confounding factors expected to affect this relationship in different logistic regression models. Model 1 was adjusted for sociodemographic characteristics including age, gender, marital status, education level, monthly income, and length of service. Model 2 included additional adjustments for the following behavioral risk factors: BMI, smoking status, and alcohol consumption. Model 3 included additional adjustments for occupational stress: psychosocial work characteristics (RO, RI, RA, RB, R and PE); occupational strain (VS, PYS, IS and PHS); personal resources (recreation, self-care, social support, and rational/cognitive coping). Model 4 included additional adjustments for comorbid disease, and sleep-promoting agents. We further tested the interaction between insomnia and objective short sleep duration using logistic regression models, and used persons with sleep duration ≥7 h and without insomnia as a common reference group. We calculated the odds ratios (ORs) and the 95% confidence intervals (CIs) from the four models to estimate the risk of poor work ability associated with different combination of sleep difficulty and objective sleep duration, after adjusting for all confounding factors.

Results

The sociodemographic, psychosocial, work and sleep characteristics of all participants, based on sleep difficulty and duration, are presented in Table 1. The estimated prevalence of DSM- IV-defined insomnia and sleep duration was 24.0% and 16%, respectively. Objective short sleep duration was found in 50.9% of the participants. Work ability was good in 79.5% of the participants and poor in 20.5%.

Insomnia was associated with a significantly higher risk of poor work ability (OR 1.51, 95% CI 1.17–2.04) in the first basic covariable adjusted model (Model 1, Table 2). As the number of potential confounding factors in the model increased, the OR of insomnia and poor work ability remained similar (from 1.44 to 1.34). The association between sleep duration <7 h and work ability is presented in Table 3. After adjusting for all potential confounding factors, a sleep duration of 6–7 h was associated with a nonsignificant increase in risk of poor work ability (OR 0.92, 95% CI 0.74–1.41), whereas a sleep duration 5–6 h and <5 h increased the risk by ~20% (OR 1.20, 95% CI 1.07–2.25) and ~49%(OR 1.49, 95% CI 1.13–3.72), respectively, compared with the group that slept ≥7 h.

Table 4 shows the estimated risk of poor work ability associated with different combinations of sleep difficulty and objective short sleep duration, after adjusting for age, gender, marital status, education level, monthly income, length of service, BMI, smoking status, alcohol consumption, RO, RI, RA, RB, R, PE, VS, PSY, IS, PHS, RE, SS, SC, RC, comorbid disease and sleep-promoting agent utilization. The presence of both insomnia and sleep duration <5 h increased the risk of poor work ability by ~300% (OR 3.43, 95% CI 1.87–5.23) compared with the group without insomnia and who slept ≥ 7 h. Those sleeping 5–6 h (OR 2.03, 95% CI 1.42–2.67) and 6–7 h (OR 1.69, 95% CI 1.23–2.53) and ≥7 h (OR 1.42, 95% CI 1.08–1.97) with insomnia had an increased risk of poor work ability. Finally, sleep duration of 6–7 h without insomnia in subjects was associated with a significantly increased risk of poor work ability (OR 1.65, 95% CI 1.18–2.21). The risk increased slightly in those who slept 5–6 h (OR 1.81, 95% CI 1.12–2.56) or <5 h (OR 1.90, 95% CI 1.26–4.21).

Discussion

Our findings indicate that insomnia associated with objective short sleep duration is a significant risk factor for poor work ability. This increased risk is independent of confounding factors frequently related with insomnia or work ability, such as sociodemographic and work

Table 2
Multivariable adjusted OR (95% CI) for poor work ability and insomnia (n = 2820).

Sleep difficulty	n	Model 1		Model 2		Model 3		Model 4	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Normal sleeping	692	1.00		1.00		1.00		1.00	
Insomnia	2128	1.51	1.17, 2.04	1.44	1.17, 1.98	1.38	1.09, 1.87	1.34	1.07, 2.25
P		<0.001		<0.001		<0.001		<0.001	

Model 1: adjusted for age, gender, marital status, education level, monthly income, and length of service.
Model 2: adjusted for age, gender, marital status, education level, monthly income, length of service, BMI, smoking status, alcohol use, role overload, role insufficiency, role ambiguity, role boundary, responsibility and physical environment.
Model 3: adjusted for age, gender, marital status, education level, monthly income, length of service, BMI, smoking status, alcohol use, role overload, role insufficiency, role ambiguity, role boundary, responsibility, physical environment, vocational strain, psychological strain, interpersonal strain and physical strain.
Model 4: adjusted for age, gender, marital status, education level, monthly income, length of service, BMI, smoking status, alcohol use, role overload, role insufficiency, role ambiguity, role boundary, responsibility, physical environment, vocational strain, psychological strain, interpersonal strain, physical strain, recreation, self-care, social support, and rational/cognitive coping, comorbid disease and use of sleep-promoting agents.

characteristics, behavioral risk factors and personal resources. Our results are in line with previous studies confirming the significance of insomnia for work ability [6–9]. However, in these preliminary studies, insomnia was not always clearly defined. The people with insomnia were heterogeneous, and they were not always assessed according to DSM-IV. The associations between insomnia and short sleep duration and work ability in these studies could have been driven by psychopathology [36] and use of sleep-promoting medication [37], because they are closely linked with sleep disturbance.

In our study, insomnia (with a prevalence of 24.5%) was associated with a significant risk of poor work ability (OR 1.34). When we included objective short sleep duration in the definition of insomnia, we noted a significant effect on the association of insomnia with poor work ability. In participants with insomnia who slept <5 h, 5–6 h or 6–7 h, the risk of poor work ability was 300%, 200% or 160% higher than in those who slept ≥7 h and who had normal sleeping patterns. Thus, we suggest that there was a significant synergistic interaction between insomnia and objective short sleep duration that was associated with poor work ability. To the best of our knowledge, this is the first study to combine objective short sleep duration and insomnia when examining their association with declining work ability.

With respect to the combination of insomnia and normal sleep duration, our results are partly consistent with previous studies in which insomnia symptoms with subjective sleep duration of 7 h resulted in an increased risk of sickness absence and disability retirement [13,14]. Several cohort studies have also shown that insomnia with objective normal sleep duration (>6 h) is associated with cognitive–emotional and cortical arousal such as sleep misperception and an anxious-ruminative profile, but not with physical sequelae (e.g., hypertension, diabetes, neurocognitive deficits, and increased mortality) [17–20]. Based on these early studies, we speculated that the mechanism of work ability deterioration was different between insomnia with objective normal sleep duration and insomnia with objective short duration. The findings also challenge us to think carefully about how the two subtypes of insomnia influence work ability.

Previous studies have assessed the association of short sleep duration with work ability, but they have reported inconsistent results. Some studies have shown that objective short sleep duration is associated with impaired neurobehavioral performance [38], metabolic disorders [39] and obesity [40], cardiovascular disease [41] and mental disorders [42]; all of which predispose towards poor work ability [43]. However, a few cohort studies have reported no association between subjective short sleep duration and sickness absence [14] or work disability [13]. In our study, we found that objective short sleep duration, particularly <6 h, was associated with poor work ability. One possible explanation is methodological differences for sleep duration in previous studies. In previous studies, short sleep duration was measured with subjective self-report and did not reflect true sleep loss because subjective short sleep duration was also influenced by sleep complaints, emotional and social stress, and unhealthy behavior [1]; subjects was a heterogeneous group, comprising those that perceived impairment and those who did not, as well as those who considered that they were naturally short sleepers, and those who chose that sleep pattern to meet other demands. However, in our study, sleep duration was based on three nights of Watch-PAT-200, which should better represent the typical sleep profile of the subjects. Although objective sleep duration based on PSG was used as an internally valid marker of the severity of insomnia, high cost, long waiting lists, and the requirement of one night of hospitalization limited the use of PSG [17,18]. Thus, PSG is not recommended for measurement of optimal sleep duration in the general population. In our study, we used less expensive and more practical unattended portable devices, sun as the Watch-PAT-200. Previous studies have shown that there were no significant differences in total sleep time compared with the Watch-PAT and standard PSG [27,44]. Another possible explanation for the discrepancy between the present and previous results is that the effect of short sleep on work ability differs

Table 3
Multivariable adjusted OR (95% CI) of poor work ability and objective sleep duration (n = 2820).

Sleep duration	n	Model 1		Model 2		Model 3		Model 4	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
≥7 h	1382	1.00		1.00		1.00		1.00	
6–7 h	931	1.61	1.30, 2.04	1.17	0.89, 1.54	1.25	0.87, 1.72	0.92	0.74, 1.41
5–6 h	395	2.26	1.77, 3.37	1.79	1.41, 2.53	1.62	1.41, 2.72	1.20	1.07, 2.25
<5 h	112	2.66	1.27, 3.46	1.96	1.31, 3.22	1.77	1.25, 2.87	1.49	1.13, 3.72
P		<0.001		<0.001		<0.001		<0.001	

Model 1: adjusted for age, gender, marital status, education level, monthly income, and length of service.
Model 2: adjusted for age, gender, marital status, education level, monthly income, length of service, BMI, smoking status, alcohol use, role overload, role insufficiency, role ambiguity, role boundary, responsibility and physical environment.
Model 3: adjusted for age, gender, marital status, education level, monthly income, length of service, BMI, smoking status, alcohol use, role overload, role insufficiency, role ambiguity, role boundary, responsibility, physical environment, vocational strain, psychological strain, interpersonal strain and physical strain.
Model 4: adjusted for age, gender, marital status, education level, monthly income, length of service, BMI, smoking status, alcohol use, role overload, role insufficiency, role ambiguity, role boundary, responsibility, physical environment, vocational strain, psychological strain, interpersonal strain, physical strain, recreation, self-care, social support, and rational/cognitive coping, comorbid disease and use of sleep-promoting agents.

Table 4
Joint associations of objective sleep duration and insomnia with poor work ability, OR and 95% CI (n = 2820).

Sleep difficulty	Sleep duration	n	Model 1		Model 2		Model 3		Model 4	
			OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Normal sleeping	≥7 h	1090	1.00		1.00		1.00		1.00	
Insomnia	≥7 h	292	3.16	2.24, 4.31	2.55	1.72, 3.41	2.16	1.42, 3.01	1.42	1.08, 1.97
Normal sleeping	6–7 h	689	2.25	1.66, 3.04	1.85	1.30, 2.63	1.67	1.20, 2.41	1.65	1.18, 2.21
Insomnia	6–7 h	242	2.86	2.34, 4.87	2.23	1.42, 3.32	1.89	1.12, 2.28	1.69	1.23, 2.53
Normal sleeping	5–6 h	277	2.61	1.82, 3.79	2.01	1.19, 2.72	1.92	1.11, 2.43	1.81	1.12, 2.56
Insomnia	5–6 h	118	2.67	1.61, 4.82	2.30	1.56, 2.72	2.10	1.47, 3.05	2.03	1.42, 2.67
Normal sleeping	<5 h	72	3.56	2.25, 6.32	2.74	1.34, 5.40	2.20	1.42, 6.32	1.90	1.26, 4.21
Insomnia	<5 h	40	5.75	2.81, 9.45	3.21	1.86, 5.09	3.11	1.79, 5.37	3.43	1.87, 5.23
P			<0.001		<0.001		<0.001		<0.001	

Model 1: adjusted for age, gender, marital status, education level, monthly income, and length of service.
Model 2: adjusted for age, gender, marital status, education level, monthly income, length of service, BMI, smoking status, alcohol use, role overload, role insufficiency, role ambiguity, role boundary, responsibility and physical environment.
Model 3: adjusted for age, gender, marital status, education level, monthly income, length of service, BMI, smoking status, alcohol use, role overload, role insufficiency, role ambiguity, role boundary, responsibility, physical environment, vocational strain, psychological strain, interpersonal strain and physical strain.
Model 4: adjusted for age, gender, marital status, education level, monthly income, length of service, BMI, smoking status, alcohol use, role overload, role insufficiency, role ambiguity, role boundary, responsibility, physical environment, vocational strain, psychological strain, interpersonal strain, physical strain, recreation, self-care, social support, and rational/cognitive coping, comorbid disease and use of sleep-promoting agents.

with ethnicity. According to several reports based on data from National Health Interview Survey in America [45–47], the prevalence of short sleep duration has been shown to vary by ethnicity. For instance, blacks were more likely to experience short sleep duration than whites (37% vs. 28%), which were lower than the rate of 50.9% in our working population, and black short sleepers had greater the risk of functional impairment than their white counterparts [47]. Some studies have reported that long sleep duration is also associated with increased risk of poor work ability [12,13,14]. We did not analyze the risk associated with long sleep duration because few workers slept for >9 h.

One of the strengths of our study was that insomnia was defined by clinical diagnosis, which led to reliable results. This compares favorably with previous studies in which diagnosis of insomnia was based on subjective reports of sleep quality and duration and assessed via questionnaires and/or sleep diaries. Another strength of this study was that objective sleep duration in the study was based on three nights of Watch-PAT-200, which may be a good representative of the subjects' typical or optimal objective sleep duration, and eliminate the"first night effect" effect. Some limitations should be taken into account when interpreting our results. First, because of the cross-sectional nature of the study, our results do not immediately indicate a causal relationship of insomnia and sleep duration with poor work ability, but rather a probable association. Second, our study, due to the relatively small number of subjects with long sleep duration did not have the statistical power to explore whether long sleep duration (i.e., sleep duration >9 h) is associated with poor work ability. Additionally, the study may have suffered from selection bias. Participants were blue-collar manufacturing employees working in a city with a relatively homogeneous socioeconomic status, and are not representative of the entire Chinese workforce. It is possible the associations would be different in white-collar or other non-manufacturing employees, given that occupation has a strong effect on sleep duration and sleep-related problems [48]. Consequently, generalizability of our findings to other employee groups is limited or has to be made with caution. Third, as with other studies in occupational settings, the "healthy worker effect" could not be avoided. Although both insomnia patients and normal sleepers were selected from the same working population, we cannot exclude the possibility that unhealthy workers, with poor sleep health or with poor work ability might have retired from or left their job and, as a result, there might be the effect of healthy workers. Fourth, our adjustments most likely did not capture and fully attenuate all possible confounding from chronic somatic or psychiatric conditions. Information on comorbidity was self-reported in our study. If such diagnoses and symptoms were under-reported, the effects of insomnia may in turn have been overestimated. Furthermore, some confounding variables that may have an impact on insomnia and work ability, such as hours of work, physical working conditions, personal and family history of insomnia and personality traits, were not included in the broad range of other confounders in this study. Finally, we did not have information on other primary sleep disorders such as sleep apnea or restless legs, which have been associated with work performance. Future studies are needed to clear the association between sleep duration, obstructive sleep apnea and restless legs syndrome, and the contribution of insomnia to the sleep–work ability relationship.

In conclusion, both insomnia and objective short sleep duration were independently associated with poor work ability. There was a significant synergistic interaction between insomnia and objective short sleep duration that associated with poor work ability and this relationship remained significant even after adjustment for a range of potential confounders. Given the high prevalence of insomnia in the working population and the widespread misconception of a disorder of the "worried well," its prevention and appropriate treatment should become the target of occupation health policy. Our study deepened our understanding of the relationship of insomnia and sleep duration with work ability. Even if the cause–effect relationships are still unclear, treatment of insomnia at work and improving sleep habits might be beneficial for promoting work ability.

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Conflict of interest

The authors declare that they have no conflict of interest.

References

[1] Ohayon MM. Epidemiology of insomnia: what we know and what we still need to learn. Sleep Med Rev 2002;6:97–111.
[2] Kronholm E, Partonen T, Laatikainen T, Peltonen M, Härmä M, Hublin C, et al. Trends in self-reported sleep duration and insomnia-related symptoms in Finland from 1972 to 2005: a comparative review and re-analysis of Finnish population samples. J Sleep Res 2008;17:54–62.
[3] Sivertsen B, Krokstad S, Mykletun A, Overland S. Insomnia symptoms and use of health care services and medications: the HUNT-2 study. Behav Sleep Med 2009;7:210–22.

[4] Kucharczyk ER, Morgan K, Hall AP. The occupational impact of sleep quality and insomnia symptoms. Sleep Med Rev 2012;16:547–59.
[5] Bolge SC, Doan JF, Kannan H, Baran RW. Association of insomnia with quality of life, work productivity, and activity impairment. Qual Life Res 2009;18:415–22.
[6] Salo P, Oksanen T, Sivertsen B, Hall M, Pentti J, Virtanen M, et al. Sleep disturbances as a predictor of cause-specific work disability and delayed return to work. Sleep 2010;33:1323–31.
[7] Kessler RC1, Berglund PA, Coulouvrat C, Hajak G, Roth T, Shahly V, et al. Insomnia and the performance of US workers: results from the America Insomnia Survey. Sleep 2011;34:1161–71.
[8] Ustinov Y, Lichstein KL, Wal GS, Taylor DJ, Riedel BW, Bush AJ. Association between report of insomnia and daytime functioning. Sleep Med 2010;11:65–8.
[9] Rahkonen O, Lallukka T, Kronholm E, Vahtera J, Lahelma E, Laaksonen M. Sleep problems and sickness absence among middle-aged employees. Scand J Work Environ Health 2010;38:47–55.
[10] Cappuccio FP, Cooper D, D'Elia L, Strazzullo P, Miller MA. Sleep duration predicts cardiovascular outcomes: a systematic review and meta-analysis of prospective studies. Eur Heart J 2011;32:1484–92.
[11] Grandner MA, Patel NP, Gehrman PR, Perlis ML, Pack AI. Problems associated with short sleep: bridging the gap between laboratory and epidemiological studies. Sleep Med Rev 2010;14:239–47.
[12] Vahtera J, Pentti J, Helenius H, Kivimäki M. Sleep disturbances as a predictor of long-term increase in sickness absence among employees after family death or illness. Sleep 2006;29:673–82.
[13] Haaramo P, Rahkonen O, Lahelma E, Lallukka T. The joint association of sleep duration and insomnia symptoms with disability retirement: a longitudinal register-linked study. Scand J Work Environ Health 2012;38:427–35.
[14] Lallukka T, Haaramo P, Rahkonen O, Sivertsen B. Joint associations of sleep duration and insomnia symptoms with subsequent sickness absence: the Helsinki Health Study. Scand J Public Health 2013;41:516–23.
[15] Sivertsen B, Øverland S, Pallesen S, Bjorvatn B, Nordhus IH, Maeland JG, et al. Insomnia and long sleep duration are risk factors for later work disability. the Hordaland Health Study. J Sleep Res 2009;18:122–8.
[16] Lauderdale DS, Knutson KL, Yan LL, Liu K, Rathouz PJ. Self-reported and measured sleep duration: how similar are they? Epidemiology 2008;19:838–45.
[17] Fernandez-Mendoza J, Vgontzas AN, Liao D, Shaffer ML, Vela-Bueno A, Basta M, et al. Insomnia with objective short sleep duration and incident hypertension: the Penn State Cohort. Hypertension 2012;60:929–35.
[18] Vgontzas AN, Liao D, Pejovic S, Calhoun S, Karataraki M, Bixler EO. Insomnia with objective short sleep duration is associated with type 2 diabetes: a population-based study. Diabetes Care 2009;32:1980–5.
[19] Fernandez-Mendoza J, Calhoun S, Bixler EO, Pejovic S, Karataraki M, Liao D, et al. Insomnia with objective short sleep duration is associated with deficits in neuropsychological performance: a general population study. Sleep 2010;33:459–65.
[20] Vgontzas AN, Liao D, Pejovic S, Calhoun S, Karataraki M, Basta M, et al. Insomnia with short sleep duration and mortality: the Penn State cohort. Sleep 2010;33:1159–64.
[21] Ilmarinen J. Work ability — a comprehensive concept for occupational health research and prevention. Scand J Work Environ Health 2009;35:1–5.
[22] Tuomi K, Ilmarinen J, Jahkola A, Katajarinne L, Tulkki A. Work Ability Index. 2nd ed. FIOH: Finland; 1998.
[23] Bethge M, Radoschewski FM, Gutenbrunner C. The Work Ability Index as a screening tool to identify the need for rehabilitation: longitudinal findings from the Second German Sociomedical Panel of Employees. J Rehabil Med 2012;44:980–7.
[24] Soldatos CR, Dikeos DG, Paparrigopoulos TJ. Athens Insomnia Scale: validation of an instrument based on ICD-10 criteria. J Psychosom Res 2000;48:555–60.
[25] Chung KF, Kan KK, Yeung WF. Assessing insomnia in adolescents: comparison of Insomnia Severity Index, Athens Insomnia Scale and Sleep Quality Index. Sleep Med 2011;12:463–70.
[26] Wei CY, Chung TC, Wu SC, Chung CF, Wu WP. The subjective sleep quality and heart rate variability in hemodialysis patients. Ren Fail 2011;33:109–17.
[27] Yuceege M, Firat F, Demir A, Ardic S. Reliability of the Watch-PAT 200 in detecting sleep apnea in highway bus drivers. J Clin Sleep Med 2013;9:339–44.
[28] Bar AB, Pillar G, Dvir I, Sheffy J, Schnall RP, Lavie P. Evaluation of a portable device based on peripheral arterial tone for unattended home sleep studies. Chest 2003;123:695–703.
[29] Xiang YT, Ma X, Lu JY, Cai ZJ, Li SR, Xiang YQ, et al. Relationships of sleep duration with sleep disturbances, basic socio-demographic factors, and BMI in Chinese people. Sleep Med 2009;10:1085–9.
[30] Ma LJ, Zhou T, Jin TY, Shen GZ, JI XP. Reliability and validity of Work Ability Index in Chinese version. J Labour Med 2000;17:70–2 (In Chinese).
[31] Kaleta D, Makowiec-Dabrowska T, Jegier A. Lifestyle index and work ability. Int J Occup Med Environ Health 2006;19:170–7.
[32] De Zwart BC, Frings-Dresen MH, van Duivenbooden JC. Test–retest reliability of the Work Ability Index questionnaire. Occup Med (Lond) 2002;52:177–81.
[33] Ospow SH. Occupational stress inventory. revised ed. Odessa (FL): Psychological Assessment Resources, Inc.; 1998.
[34] Wu H, Zhao Y, Wang J, Wang L. Factors associated with occupational stress among Chinese doctors: a cross-sectional survey. Int Arch Occup Environ Health 2010;83:155–64.
[35] Yang XW, Wang ZM, Jin TY, Lan YJ. Study on the occupational stress norm and it's application for the marketing group, public service/safety group and production laborer group. Wei Sheng Yan Jiu 2006;35:594–8 (In Chinese).
[36] Roth T. Comorbid insomnia: current directions and future challenges. Am J Manag Care 2009;15:S6–S13 [Suppl.].
[37] Wichniak A, Wierzbicka A, Jernajczyk W. Patients with insomnia and subthreshold depression show marked worsening of insomnia after discontinuation of sleep promoting medication. Prog Neuropsychopharmacol Biol Psychiatry 2011;35:1671–6.
[38] Boonstra TW, Stins JF, Daffertshofer A, Beek PJ. Effects of sleep deprivation on neural functioning: an integrative review. Cell Mol Life Sci 2007;64:934–46.
[39] Spiegel K, Leproult R, Van Cauter E. Impact of sleep debt on metabolic and endocrine function. Lancet 1999;354:1435–9.
[40] Spiegel K, Knutson K, Leproult R, Tasali E, Van Cauter E. Sleep loss: a novel risk factor for insulin resistance and type 2 diabetes. J Appl Physiol 2005;99:2008–19.
[41] van Leeuwen WM, Lehto M, Karisola P, Lindholm H, Luukkonen R, Sallinen M, et al. Sleep restriction increases the risk of developing cardiovascular diseases by augmenting proinflammatory responses through IL-17 and CRP. PLoS One 2009;4:e4589.
[42] Franzen PL, Siegle GJ, Buysse DJ. Relationships between affect, vigilance, and sleepiness following sleep deprivation. J Sleep Res 2008;17:34–41.
[43] Gould R, Ilmarinen J, Järvisalo J, Koskinen S. Dimensions of work ability: results of the Health 2000 Survey. Finland: Waasa Graphics Oy; 2008.
[44] Körkuyu E, Düzlü M, Karamert R, Tutar H, Yılmaz M, Ciftçi B, et al. The efficacy of Watch PAT in obstructive sleep apnea syndrome diagnosis. Eur Arch Otorhinolaryngol 2014. http://dx.doi.org/10.1007/s00405-014-3097-0.
[45] Jackson CL, Redline S, Kawachi I, Williams MA, Hu FB. Racial disparities in short sleep duration by occupation and industry. Am J Epidemiol 2013;178:1442–51.
[46] Luckhaupt SE, Tak S, Calvert GM. The prevalence of short sleep duration by industry and occupation in the National Health Interview Survey. Sleep 2010;33:149–59.
[47] Brimah P, Oulds F, Olafiranye O, Ceide M, Dillon S, Awoniyi O, et al. Sleep duration and reported functional capacity among black and white US adults. J Clin Sleep Med 2013;9:605–9.
[48] Luckhaupt SE, Tak S, Calvert GM. The prevalence of short sleep duration by industry and occupation in the National Health Interview Survey. Sleep 2010;33:149–59.